APPLICATION

OF

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ON

SYSTEM FOR, AND METHOD OF, IRRADIATING ARTICLES

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This invention relates to systems for, and methods of, irradiating products, including food products, to make them safe to use or eat. The invention particularly relate to systems for, and methods of, providing the irradiation within particular limits regardless of irregularities in the characteristics, including irregularities in the geometric shape, of the products including the food products.

BACKGROUND OF A PREFERRED EMBODIMENT OF THE INVENTION

It has been known for some time that drugs and medical instruments and implements have to be irradiated so that they will not cause patients to become ill from harmful bacteria when they are applied to the patients. Systems have accordingly been provided for irradiating drugs and medical instruments and implements. The drugs and the medical instruments and implements have then been stored in sterilized packages until they have been ready to be used.

In recent years, it has been discovered that foods can carry harmful bacteria if they are not processed properly or, even if they are processed properly, that the foods can harbor and foster the proliferation of such harmful bacteria if they are not stored properly

or retained under proper environmental conditions such as temperature. Some of the harmful bacteria can even be deadly.

For example, harmful bacteria have been discovered in recent years in hamburgers prepared by one of the large hamburger chains. Such harmful bacteria have caused a number of purchasers of hamburgers at stores in the chain to become sick. As a result of this incident and several other similar incidents, it is now recommended that hamburgers should be cooked to a well done state rather than a medium rare or rare state. Similarly, harmful bacteria have been found to exist in many chickens that are sold to the public. As a result of a number of incidents which have recently occurred, it is now recommended that all chickens should be cooked until no blood is visible in the cooked chickens.

To prevent incidents such as discussed in the previous paragraphs from occurring, various industries have now started to irradiate foods before the goods are sold to the public. This is true, for example, of hamburgers and chickens. It is also true of fruits, particularly fruits which are imported into the United States from foreign countries.

In previous years, gamma rays have generally been the preferred medium for irradiating various articles. The gamma rays have been obtained from a suitable material such as cobalt and have been directed to the articles to be irradiated. The use of gamma rays has had certain disadvantages. One disadvantage is that irradiation by gamma rays is slow. Another disadvantage is that irradiation by gamma rays is not precise. This results in part from the fact that the strength of the source (e.g. cobalt) of the gamma rays decreases over a period of time and that the gamma rays cannot be directed in a sharp beam to the article to be irradiated. This prevents all of the gamma rays from being useful in irradiating the articles.

In recent years, electron beams have been directed to articles to irradiate the articles. Electron beams have certain advantages over the use of gamma rays to irradiate articles. One advantage is that irradiation by electron beams is fast. For example, a chub having a square cross section can be instantaneously irradiated by a passage of an electron beam of a particular intensity through the chub. Another advantage is that irradiation by an electron beam is relatively precise because the strength of the electron beam remains substantially constant even when the electron beam continues to be generated over a long period of time.

X-rays have also been used to irradiate articles. The x-rays may be formed from electron beams. An advantage in irradiating articles with x-rays is that the articles can be relatively thick. For example, x-rays can irradiate articles which are thicker than the articles which are irradiated by electrons.

A problem has occurred in the past whether the irradiation has been provided by gamma rays, electrons or x-rays. This has occurred when the articles have had irregular characteristics such as irregular geometrical configurations. For example, a chub is generally circular in vertical section. This has caused the thickness of the chub to be different at every position in a radial direction in the cylindrical shape of the chub These differences in thickness have affected the radiation which the chubs have received at the different positions.

The radiation received at every position in an article should be within particular minimum and maximum limits. If the radiation received at any position within the article is below the particular minimum limit, the harmful bacteria in the article are not destroyed. If the radiation received at any position in the article is above the particular maximum limit, quality or organoleptic characteristics of the article may be adversely

affected. It is difficult to maintain the radiation dose in the article within the particular minimum and maximum limits when the article has irregularities in the characteristics at the different positions such as irregularities in the geometric configuration of the article. For example, a chub having a cylindrical configuration may be considered to have irregularities in characteristics because the vertical dimensions of the chub at the progressive positions of the chub in the horizontal direction are different.

BRIEF DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

An article has irregular characteristics such as an irregular geometrical configuration. Radiation from a source is directed in a particular direction toward the article. The radiation energy passing from the source to the article at different positions in the article is absorbed in accordance with the irregularities in the characteristics of the article at the different positions to maintain the dosage absorbed at the different positions in the article within particular limits.

For irregularities of a geometrical configuration in the article, the absorption may be provided by a fixture having a geometrical configuration which constitutes the difference at every position between a substantially constant value and the geometrical

configuration of the article at this position. The absorption may be provided by conveying the article and the fixture past the radiation source in a direction substantially perpendicular to the direction of the radiation from the source.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 is a simplified perspective view showing a system of the prior art for conveying an article (e.g. a chub) past a source of radiation to irradiate the article;

Figure 2 is a simplified view illustrating how a system of the prior art irradiates an article such as a chub having a circular configuration in a vertical section;

Figure 3 is a simplified view indicating how a system of this invention provides for an irradiation of an article such as a chub regardless of irregularities in the characteristics, such as irregularities in the geometrical configuration, of the article, thereby to provide for an irradiation of the article at the different positions in the article with a dosage within particular minimum and maximum limits;

Figure 4 is a simplified view showing how the system of this invention may include a fixture movable with the article past the radiation from the source to provide for

an irradiation of the article at different positions of the article with a dosage within the particular minimum and maximum limits; and

Figure 5 is a simplified view indicating a modification of the fixture shown in Figure 4.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Figure 1 is a simplified diagram of an irradiation system, generally indicated at 10, of the prior art for conveying an article past a source of radiation 12. For example, the conveyor system may be constructed as shown and described in patent 5,396,074 issued on March 7, 1995, and assigned of record to the assignee of record of this application. The conveyor system 10 includes a conveyor 14 for moving articles 16 (e.g. chubs) past the radiation source 12 for irradiation of the articles by the source. The articles may be moved past the radiation source at a substantially constant speed within particular limits. The distance between successive articles on the conveyor 14 may be maintained at a minimal value within particular limits. The articles 16 may be irradiated with gamma rays, electrons or x-rays or any other type of radiation without departing from the scope of the invention.

The articles 16 may have irregular characteristics at different positions. These irregular characteristics may include irregularities in geometrical configuration. For example, the articles 12 may constitute chubs having a cylindrical shape. The radiation from the source may pass through each chub in a vertical direction corresponding to the circular cross sections of the chub.

Figure 2 illustrates a cross section view of the article 16 in the vertical direction when the article is a chub. The chub moves in a direction 17 past the accelerator 12. The direction is perpendicular to the direction of the radiation from the accelerator 12. As will be seen, the irradiation provided at a position A in a vertical section of the chub 16 is different from the irradiation provided at a position B in a vertical section of the chub even though the positions A and B are at the same distance in Figure 2 from the accelerator 12 when the positions A and B are aligned with the accelerator. This results from the fact that the radiation has to pass through the chub 16 between the positions C and A on the one hand when the chubs move at positions C and A past the accelerator. On the other hand, the radiation has to pass only through the distances between D and B as the chub moves at the positions D and B past the accelerator.

The irradiation of the chub at the position A is accordingly different than the irradiation of the chub at the position B. This may cause the chub to be under-radiated at some positions in the chub and to be over-radiated at other positions in the chub. Under radiating in the chub is undesirable because harmful bacteria in the chub are not killed. Over-irradiating is undesirable because the quality or organoleptic characteristics of the chub may be negatively affected. It is accordingly desirable to radiate the article within particular minimum and maximum limits. This causes harmful bacteria to be killed and the quality or organoleptic characteristics of the chub to be retained.

Opposite sides of the chub 16 may be irradiated by having the chub irradiated from an opposite side of the chub. However, irradiating the chub from opposite sides of the chub does not have any effect on the dissimilarities of the radiation at the positions A and B. The reason is that the distance between E and A is the same as the distance between C and A and the distance between F and B is the same as the distance between D and B. As will be appreciated, the positions between C, A and E define a straight line and the positions between D, B and F also define a straight line. The direction between the positions C and E, and between the positions D and F, is substantially parallel to the direction of the radiation from the accelerator 12.

Co-pending application 09/710,730 filed in the U.S. Patent Office on 11/10/00 and assigned of record to the assignee of record of this application discloses and claims a member disposed between a radiation source and an article. The member absorbs the radiation from the accelerator, when the radiation is above the preferred maximum limit, so that the radiation passing through the source to the article will be within the preferred maximum and minimum limits in the article. However, the member is stationary.

This invention provides a simple but ingenious solution to the problems discussed above. In accordance with one embodiment shown in Figure 3, the article 16 (e.g. chub) is disposed in a fixture, generally indicated at 20, which may be aluminum, steel or almost any plastic material having characteristics, in response to radiation from the accelerator 12, substantially corresponding to those of the article 16. The geometrical configuration of the fixture 20 in a planar direction corresponding to the direction of the radiation from the accelerator 12 complements the geometrical configuration of the article 16 such that the combined or composite configuration of the fixture 20 and the article 14 is essentially a square in section. The article 14 does not have to be disposed snugly within the fixture 20. The fixture 20 is movable with the article 14 past the accelerator 12.

In other words, the dimension of the composite article 16 and the fixture 20 in the direction of the radiation from the accelerator source 12 is substantially the same at every position in the direction of the radiation from the accelerator 12 when the composite is moved on the conveyor past the radiation in a direction substantially perpendicular to the direction of the radiation from the source. In this way, the radiation dosage of the article 16 at the position B is the same within the maximum and minimum limits as the radiation dosage of the article at the position A. This is also true for every position along the line between B and A and at every position along the extension of this line between A and E.

The fixture 20 has at the progressive positions characteristics, including a geometric shape, constituting the difference between substantially constant characteristics and the characteristics of the article at the progressive positions. The fixture 20 is disposed relative to the article 16 to provide the substantially constant characteristics for the combination of the article and the fixture at the progressive positions in the direction substantially perpendicular to the direction of the radiation from the accelerator 12. When there are irregularities in the geometric shape of the article, the fixture is disposed relative to the article to provide a substantially constant geometric shape defined by the combination of the article and the fixture at the progressive positions in the article.

Thus, applicant absorbs the radiant energy passing from the source 12 to the article 16 at the different positions in accordance with the irregularities of the article at the different positions so as to maintain the radiation dosage at the different positions in the article within the particular limits. Applicant provides for the radiation dosage from the source within the particular limits at the different positions in the article regardless of the irregularities in the characteristics of the article at the different positions. As will be seen, applicant compensates for, or complements, the irregularities in the characteristics of the article at the different positions in the article to provide substantial uniformity in the radiation dose at the different positions in the article within the particular limits.

Applicant also accomplishes the results specified in the previous paragraph (a) by providing a fixture having irregular characteristics, including an irregular geometric shape, at progressive positions to compensate for the differences in the irregularities of the characteristics, including the irregularities in the geometric shape, of the article at the progressive positions and (b) by disposing the fixture relative to the article to provide the combination of the article and the fixture with the compensating characteristics at the progressive positions in response to the radiation.

The fixture 20 has characteristics of receiving at the progressive positions different radiation doses per unit of distance of travel of the radiation through the fixture. The different radiation doses per unit of distance for the fixture 28 correspond to the different radiation doses per unit of distance for the article to maintain, within the particular limits at the progressive positions, the radiation dosage received by the article per unit of travel of the radiation through the article.

Figure 4 illustrates a fixture, generally indicated at 22, which constitutes a modification of the fixture 20 shown in Figure 3. The fixture 22 may constitute fixtures 22a on one side of the article 14 in the direction of the radiation from the accelerator 12 and fixtures 22b on the other side of the article in the direction of the radiation from the accelerator.

When the irregularities on the opposite sides of the article 14 are symmetrical, the irregularities in the fixtures 22a and 22b are also preferably symmetrical. However, if the irregularities in the geometrical shape on the opposite sides of the article 16 are not symmetrical, the irregularities in the geometric shape of the fixtures 22a on the opposite sides of the article are correspondingly not symmetrical and the irregularities in the

geometric shape of the fixtures 22b on the opposite sides of the article are correspondingly not similar. As will be seen in Figure 4, the irregularities in the geometrical shape of the fixtures 22a and 22b extend into the irregularities of the geometrical shape of the article 14. The fixtures 22a and 22b are movable with the article 14 past the radiation from the accelerator 12, preferably in a direction substantially perpendicular to the direction of the radiation from the accelerator 12. This is indicated by an arrow 23.

In Figure 5, the fixtures 22 and 22b are combined to produce single fixtures 24a and 24b. The fixture 24a has irregularities in its geometrical shape corresponding to a combination of the irregularities in the fixtures 22a in Figure 4 at progressive positions substantially perpendicular to the direction of the radiation from the accelerator. In like manner, the fixture 24b has irregularities in its geometrical shape corresponding to a combination of the irregularities in the fixtures 22b in Figure 4 at progressive positions substantially perpendicular to the direction of the radiation from the accelerator 12. The fixtures 24a and 24b are movable with the article 14 past the accelerator 12. The fixtures 24a and 24b absorb the radiation from the accelerator 12 in a manner similar to the

combination of the absorptions provided by the fixtures 22a and 22b in Figure 4. The fixtures 24a and 24b extend into the irregular shape of the article 16.

Although this invention has been disclosed and illustrated with reference to particular embodiments, the principles involved are susceptible for use in numerous other embodiments which will be apparent to persons of ordinary skill in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.